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Computer printing and filing of microbiology reports

2 Evaluation and comparison with a manual system, and comparison of two manual systems

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SYNOPSIS A manual system of microbiology reporting with a National Cash Register (NCR) form with printed names of bacteria and antibiotics required less time to compose reports than a previous manual system that involved rubber stamps and handwriting on plain report sheets. The NCR report cost 10·28 pence and, compared with a computer system, it had the advantages of simplicity and familiarity, and reports were not delayed by machine breakdown, operator error, or data being incorrectly submitted. A computer reporting system for microbiology resulted in more accurate reports costing 17·97 pence each, faster and more accurate filing and recall of reports, and a greater range of analyses of reports that was valued particularly by the control-of-infection staff. Composition of computer-readable reports by technicians on Port-a-punch cards took longer than composing NCR reports. Enquiries for past results were more quickly answered from computer printouts of reports and a day book in alphabetical order.

A detailed comparison between a computer system and a manual system in a microbiology laboratory has not yet been reported. The unacceptable aspects of a laboratory computer system have been described by Toreson (1970) and Kobernick and Mandell (1974), but many of those who introduce a computer system are enthusiasts who minimize or ignore its constraints, its greater cost, and its disadvantages, and eulogize the benefits. A computer can do some useful things such as arrange in alphabetical order a list of specimens received or reports issued; if, however, a laboratory does not wish to make a record of specimens received there may be no advantage for the laboratory from that ability of the computer. At Northwick Park Hospital a comparative trial of manual systems and a system of computer-assisted reporting and filing (CARF) in microbiology was possible because the laboratory started work with a manual system, but the hospital already possessed two of the requirements of a computer system: patient identification by a system that was computer-readable, and available time on a computer (ICL 1903A) in the adjoining Clinical Research Centre. The trial was therefore designed to determine whether a computer method could eliminate the problems of manual methods without introducing even greater problems.

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Material and Methods

MANUAL SYSTEM A (MSA)

Northwick Park Hospital opened in September 1970; until June 1973 microbiology reports were entered on plain request/report sheets by rubber stamps and handwriting. On receipt of a specimen in the laboratory a serial number was stamped on the request form and in a 'day-book' in which were written the patient's name and details of the specimen; the number was written on the specimen. The request form was photocopied, so that a copy of the report could be kept in the laboratory file. An additional photocopy was made of a request from a general practitioner so that a copy of the report could be filed in the patient's hospital folder, to be available when the patient attended hospital.

MANUAL SYSTEM B (MSB)

From June 1973 until March 1974 for hospital specimens a request/report form was used with printed names of bacteria and antibiotics that were encircled and marked to produce a report and a

laboratory copy by the NCR system (figure). Patient details were written in the day-book as with MSA.

COMPUTER ASSISTED SYSTEM (CARF)

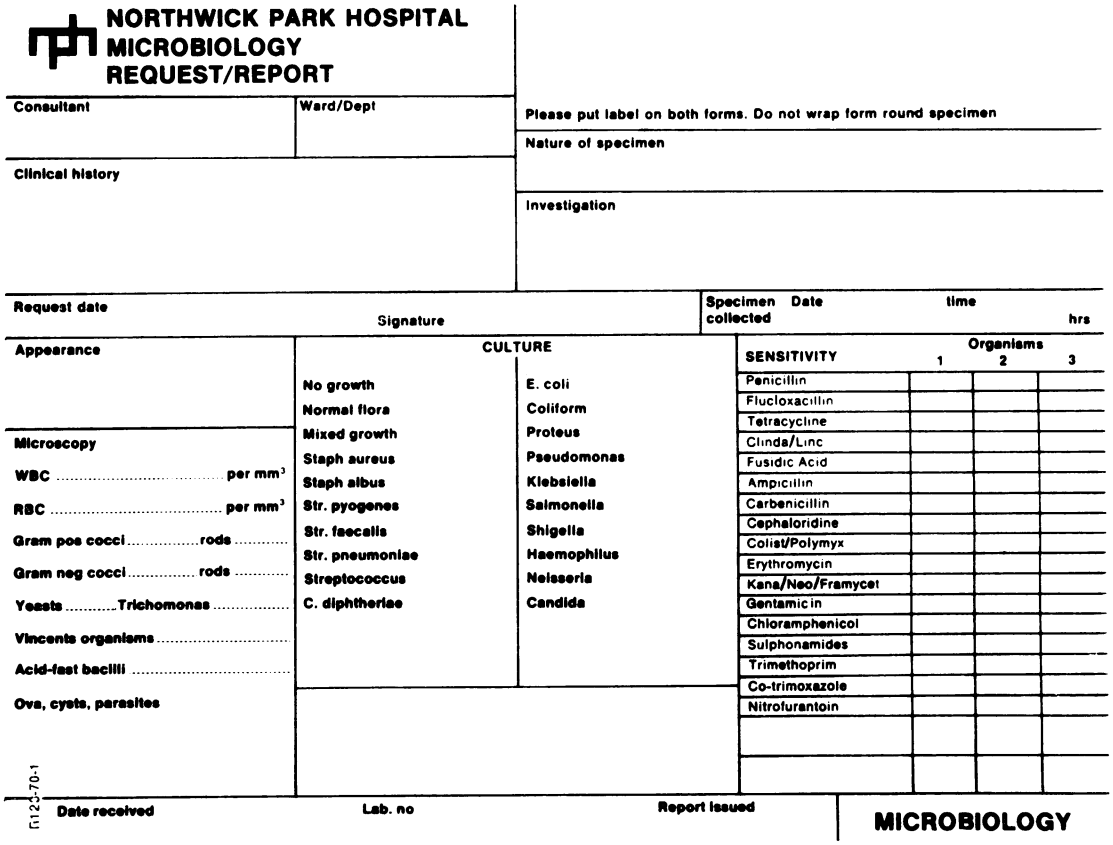
From March 1974 the system described by Goodwin and Smith (1976) was used for all specimens. CARF was most frequently compared with MSB, and in such comparisons they are referred to as 'the two systems'.

TIMING OF PROCEDURES

Registration of specimens in each system, recording of results, and retrieval from the files to answer telephone and other enquiries were timed by staff who were not normally connected with the laboratory—two university students attached to the laboratory for periods of a few months each. Each procedure was timed on at least eight occasions and a statistical analysis—Student's t test—was then made of the first four measurements compared with the last four to determine whether these differed significantly at the 5% level. It had been expected that the clerks and technicians would be more sensitive during the original timings and become either faster or slower during the four latter measurements. However, none of the procedures varied in this way. More measurements were then made and if the latter measurements remained within the range of the earlier extremes a total of 10 measurements were made for each procedure. The results were expressed as the time taken, in decimal minutes, for the work on 10 specimens.

ERRORS AND FAILURES

Reports with omissions of microbiologically important features, and errors of interpretation and transcription were investigated for the two systems. To determine whether the files contained a copy of every report, sections of the file of each system were investigated by searching for every tenth report.


NORTHWICK PARK HOSPITAL
MICROBIOLOGY
REQUEST/REPORT

Consultant | Ward/Dept

Please put label on both forms. Do not wrap form round specimen

Nature of specimen

Clinical history

Investigation

Request date | Signature | Specimen collected Date | time | hrs

Appearance

Microscopy
WBC ..... per mm³
RBC ..... per mm³
Gram pos cocci ..... rods .....
Gram neg cocci ..... rods .....
Yeasts ..... Trichomonas .....
Vincents organisms .....
Acid-fast bacilli .....
Ova, cysts, parasites

CULTURE

No growth
Normal flora
Mixed growth
Staph aureus
Staph albus
Str. pyogenes
Str. faecalis
Str. pneumoniae
Streptococcus
C. diphtheriae

E. coli
Coliform
Proteus
Pseudomonas
Klebsiella
Salmonella
Shigella
Haemophilus
Neisseria
Candida

SENSITIVITY	Organisms 1	2	3
Penicillin			
Flucloxacillin			
Tetracycline			
Clinda/Linc			
Fusidic Acid			
Ampicillin			
Carbenicillin			
Cephaloridine			
Colist/Polymyx			
Erythromycin			
Kana/Neo/Framycet			
Gentamicin			
Chloramphenicol			
Sulphonamides			
Trimethoprim			
Co-trimoxazole			
Nitrofurantoin			

F125-70-1

Date received | Lab. no | Report issued

MICROBIOLOGY

Figure *NCR request/report form for MSB*

CONVENIENCE OF USE AND COST

The floor space required for filing laboratory copies and office equipment was measured for the two systems. The cost of both was analysed on the basis of their running costs for 60 000 reports per year—at 1974 prices, because MSB ended in that year.

Results

IN THE OFFICE

Specimen registration

The time required to register 10 specimens for the three systems is shown in table I. For 200 specimens a day CARF required 54 minutes more than MSB, but for CARF up to 40% of specimens arrived without machine-readable patient details and these could not be registered as quickly as other specimens because the details had to be typed. In this group of specimens 18% arrived without a complete hospital number and check letter, a disadvantage of not having patient details in a computer file on-line to the laboratory. Correction of CARF errors in specimen registration required on average 15 minutes a day; and this system required the extra procedure of arranging the request forms in numerical order before the reports were signed (table I) so that the clinical details were conveniently available during signing—a requirement by the head of the department—the reports having been printed in numerical order. Subsequently most forms were kept together in numerical order and thus were filed more quickly.

In the office there was another difference between the two systems: writing MSB specimen details in the day-book could be performed by technicians when the clerk was not available, but only a few technicians learned to register CARF specimens in computer-readable form. For the latter system office staff spent a greater part of their time registering specimens while for MSB a greater part of their time was spent answering enquiries (see below and table II). For 60 000 specimens a year, CARF produced too much work for one data-processing operator (DPO) but the clerk typist who labelled specimens and filed forms readily learned to register specimens, so that difficulty was not experienced during holidays or sickness of the DPO. MSB results of culture for Mycobacteria and other 'continuation' reports required the specimen details to be typed on a new form, for which 20 minutes a day was required.

The product of the registration procedure differed between the two systems: in the CARF day-book the entries were sorted by the computer into alphabetical order; in the MSB day-book they remained in the order of arrival. At the end of each week all the CARF entries were re-sorted to produce a weekly alphabetical day-book. The usefulness of a list in alphabetical order is discussed under 'Retrieval of reports' below; but it is evident that it would be quicker to find a name in an alphabetical list than in a list in order of arrival, as with MSB.

Distribution of reports to the wards

For the manual systems the technicians wrote reports that were in a form that could be signed by the laboratory doctor and sent immediately to the wards. For CARF an extra procedure was required—collection of paper-tape and punched cards, submission to the computer, and printing of reports.

Procedure	*Number of Observations*	*MSA Times (min)*		*MSA and MSB*	*MSB Times (min)*		*CARF Times (min)*		*CARF and MSB*
		Range	*Mean*	P	*Range*	*Mean*	*Range*	*Mean*	P
Registration	10	9·27-14·12	10·53	<0·001	4·40-10·00	6·17	6·90-10·60	8·60	<0·002
Sorting forms before signature	10	UN			UN		1·20- 1·90	1·40	
Filing forms after signature	10	2·00- 3·30	2·50	NS	2·14- 3·22	2·42	1·44- 2·42	1·73	<0·05
Total			13·03			8·59		11·73	

Table I *Time required to register and file 10 request/report forms*

UN = unnecessary

Reports issued	*Number of Observations*	*MSB Times (min)*		*CARF Times (min)*		P
		Range	*Mean*	*Range*	*Mean*	
1-7 days previously	20	1·0-21·7	8·6	1·0-3·0	1·5	<0·05
1-4 weeks previously	20	1·0-19·5	5·5	0·7-2·5	1·27	<0·02
6-12 months previously	20	1·7-5·3	3·3	0·8-2·8	1·42	>0·1

Table II *Time required to find a copy of a report*

In this hospital, reports are collected from the laboratory at 11.00, 14.00, and 17.00 hours. For the manual systems some reports were available by 11.00 hours, but for CARF, with limited access to the computer, reports were not available until 12.00 hours and so were collected at 14.00 hours. For CARF the production of the reports could be delayed by a mechanical fault in the computer, or an error by a computer operator, or by a delay in the availability of the machine. On average, once a month reports were printed at a later time, which resulted in their not being available for collection by 14.00 hours. Medical staff were asked whether they had noticed that CARF reports were available later than manual reports; they had not noticed this.

Filing

The time required to file 10 request forms with each system is shown in table I; for the manual systems, forms were filed in alphabetical order, but CARF forms were filed in numerical order. MSB required significantly more time for filing than CARF. From table I it can be calculated that for filing, after being signed, 200 forms a day MSB required 13.8 minutes more than CARF, and this is a significant difference; but for sorting and filing CARF required 14.2 minutes more than MSB.

The completeness of the files was analysed as described in Methods. In the MSB file 10 out of 300 forms (3.3%) could not be found; in the computer file only one out of 300 (0.3%) was missing. One reason that an MSB form might have been misfiled was that the name on the form had been written by hand; among 500 pairs of urine specimens there were 14 occasions when the second name differed appreciably from the first—examples were Jackson and Jockson, and Salterthwaite and Satterthwaite. The missing CARF report must have been due to a combination of two failures of the system; the specimen details were rejected and remained uncorrected by the DPO or were never entered, and the subsequent card-rejection was not acted upon by the laboratory staff.

In the CARF numerical file of forms, of 2913 envelopes, six (0.2%) were misfiled, four of these being five places away from their correct place, one being 18 places away, and one being 75 places away.

Retrieval of reports

To answer an enquiry for a result on a specimen that was still being examined in the laboratory the clerk found the number of the specimen in the day-book, as this facilitated finding the culture plates and request form in the laboratory. To answer an enquiry about a specimen that had never reached the laboratory a categorical assurance had to be given that there was no record of the specimen in the day-book. For MSB a search for 10 entries in the day-book required 8 minutes, but for CARF it required only 2 minutes.

Telephone enquiries for reports were received every day, usually because the report issued by the laboratory had not reached its destination. Enquiries for reports issued up to one week previously were timed separately from enquiries for reports issued between one week and six months previously. A third group of enquiries came from laboratory staff who occasionally wished to see the copy of a report that might have been issued 6-12 months previously. CARF reports issued the previous week were accumulated in a printout in alphabetical order, and those less than a week old were in a separate daily printout, these being in folders by the office telephone. Manual copies, for several weeks after a report had been issued, could be in one of six different places, each of which might have to be visited to answer a telephone enquiry. For example, the copy could be in the laboratory, or with the control-of-infection officer or other senior laboratory staff. Filing of manual forms tended to lag behind the daily output, and each day's copies were kept in a separate clip. On at least three occasions 800-1000 copies were unfiled in up to 10 separate clips.

The times required to answer enquiries are shown in table II; for MSB the time required to retrieve reports issued up to four weeks previously was significantly longer than for CARF. In addition to the 20 observations recorded in the table for MSB there were three ocasions when the copy of a report could not be found.

To estimate the extra time required to answer MSB enquiries both systems have been analysed on the basis of 60 000 requests per year, when an average of eight telephone enquiries were made daily usually for results up to one month old, and on average with two laboratory enquiries daily for results 6-12 months old. MSB required 50 minutes more time than CARF each day. To answer MSB enquiries the office staff often had to ask for the help of technicians in the laboratory to look for a copy of a report, whereas for CARF all the copies of reports were kept in the laboratory office.

Space required for laboratory copies

For 60 000 copies in one year MSB required 18 m drawer space, while CARF required 48 m for request envelopes, and 1 m on a hanging rail for results folders. Data-processing equipment added about 3 m^2 to the office space required.

IN THE LABORATORY

Composition of reports

Specimens are examined in different parts of the

laboratory according to the type of specimen, and the composition of reports in each area was timed separately. Table III shows the time taken by technical staff to compose 10 MSA reports with rubber stamps and handwriting, 10 MSB reports by marking the NCR printed forms, and 10 CARF reports by punching Port-a-punch cards. With MSA the times required to compose urine and faeces reports were not significantly longer than those for MSB but were significantly longer for respiratory specimens ($P < 0.001$) and for general swabs ($P < 0.001$). For CARF the times to compose reports were significantly longer than MSB for all specimens except respiratory specimens; for 200 specimens a day, 18 minutes more were required for urine reports, 4 minutes more for faeces reports, 3·5 minutes more for respiratory reports, and 30 minutes more for other general reports except sera. Every day some Port-a-punch cards were punched wrongly and required correction. Each area usually corrected its own cards, but during a short time when all the cards were corrected by one person it took, on average, 50 minutes a day for the corrections.

Accuracy of reports

An analysis was not made of every possible type of error but the following are examples of the errors that were analysed.

Of 4072 urine reports by MSB there were 2505 with organisms reported; in 24 (0·95%) of these the viable count had been omitted in error. The CARF programs rejected a card containing this error, and computer reports were therefore accurate in this respect. Of 4072 urine reports by MSB, 47 (1·2%) did not contain a leucocyte count; the CARF programs rejected urine cards without a count of leucocytes and erythrocytes unless the technician had overruled this requirement by punching a special value on the card.

Of 1179 MSB reports with antibiotic sensitivities, 100 (8·5%) contained errors, usually of only one antibiotic result. The error in 3·5% of reports was one of interpretation—on the back of the form the zone of inhibition around the antibiotic disc was recorded as zero but on the front the organism was reported as sensitive, or the zone was large and the organism was reported as resistant. Another form of error was to report *Staph. aureus* as being resistant to penicillin but sensitive to ampicillin. For CARF the zone of inhibition was punched as a number on the card and the computer programs deduced whether this indicated sensitivity or resistance. Of 1000 sensitivity reports, six (0·6%) results were wrong because the technician punched zero when the zone was 10. To avoid this error with CARF the technicians were required to write either 9 or 11 in place of 10; a zone of 9 mm or greater always indicated a sensitive organism. The computer programs analysed a sensitivity report according to the type of organism; for Gram-positive cocci other than *Str. faecalis* penicillin was always printed on the report even if the zone size had been punched in the ampicillin column.

The report of a wound swab should include the result of an examination for leucocytes in a Gram-stained film; of 365 MSB reports of wound swabs, 70 (19·2%) did not contain a report of leucocytes. Any CARF card for a wound swab without a result for leucocytes was rejected unless the technician had overruled the program.

In all systems the copy kept in the laboratory should be the one with the technician's working notes on the back. Of 1361 MSB reports (to general practitioners), 118 laboratory copies (8·6%) did not have the notes on the back, the wrong copy having been sent out. In the CARF system this mistake could not happen because specimens received the GP-location code while being registered and this caused two identical reports to be printed, while working notes remained on the laboratory request form.

Delayed reports

In the MSB system there was only one major reason for reports being delayed in their distribution to the wards: technicians could overlook specimens, and tests that had not been reported; of 6046 non-serology reports, 179 (2·6%) were delayed for more than three days before being reported. For CARF there was an additional reason for reports to be delayed: rejected cards were not corrected quickly and re-submitted. Every day a list was printed of

Area	*Number of Occasions when Report-compositions were timed*	*MSA Times (min)*		*MSB Times (min)*		*CARF Times (min)*		*CARF and MSB*
		Range	*Mean*	*Range*	*Mean*	*Range*	*Mean*	P
Urine	10	3·10- 5·10	4·03	0·85-4·08	2·45	3·40- 6·03	4·48	<0·01
Faeces	10	4·03- 7·42	6·09	3·00-9·50	5·38	2·50-11·08	8·00	<0·001
Respiratory specimens	10	9·15-14·10	11·04	2·26-7·17	4·03	2·94- 8·47	5·21	<0·1
General swabs	10	4·42-11·30	8·32	2·05-5·70	4·20	9·10-22·07	12·30	<0·01

Table III *Time required to compose 10 reports*

specimens—other than serum—that had not been reported three days after the specimen was received. The speed with which technicians acted on these overdue reports varied considerably during the 15 months of the trial. The daily overdue list contained between 3 and 12 specimens (1·7-6·6%); 80% of these were due to rejected cards not being corrected quickly. Cards were rejected either because they did not contain an essential value—card errors—or because a continuation card did not match data on a previous card, or specimen details were not in the computer file—match errors (Goodwin and Smith, 1976). During the first month of CARF the proportion of card errors each day dropped from 10% to 1%, and during the next nine months it varied from 0% to 8%. The average for each week stayed in the range 2-4% of cards submitted. Daily match errors varied from 1% to 15%, but the average for each week was 5-7%.

For MSB there was one minor reason for delayed reports: specimens or isolates were posted to reference laboratories for special tests, and a delay in receiving the report for any reason might not be detected; one analysis revealed that results were still awaited from five sera that had been sent to reference laboratories more than five months previously. For CARF there were eight different overdue lists that contained details of specimens for which primary or later reports had been delayed beyond the usual time; the time at which overdue warnings were given varied according to the type of test; these lists warned technicians of delayed reports.

Acceptability, service, and quality control

The technicians were aware that the computer system was on trial and were very cooperative; the recording of laboratory tests was found to be easily understood; requests by them for changes in the specimen code and report wordings were met. Problems of the system and possible improvements were described by Goodwin and Smith (1976).

The constraints of the computer puzzled or annoyed some members of the staff. The logic required to enter computer data and disentangle error reports required an effort that was accepted on most occasions by the staff, but there was a tendency to blame 'the computer' when the reason for a card rejection was not immediately obvious.

The senior chief technician required a list of the origin of specimens for the annual return to the Department of Health. By MSB this required six hours during the year by the chief technician, and other procedures by the office staff. By CARF an enquiry pack of cards was prepared every two months to produce the same list and the preparation of this pack required five minutes. The cost of computer time for an interrogation of the computer files was on average £2.

The control-of-infection sister was informed of reports on wound swabs—60 a week—and babies' swabs. By MSB the laboratory copies of these reports were available in the laboratory for her to see. By CARF a weekly printout of each of these groups of swabs was available for her personal use (Goodwin and Smith, 1976).

Laboratory procedures could be monitored by CARF by scrutiny of the cumulative weekly printout of results, or a printout of wound swabs. Serial specimens from a patient might yield the same organism; occasionally the antibiotic sensitivities on consecutive isolates were seen to be different; this led to an enquiry to find the reason, and, if a mistake was found, steps could be taken to prevent conflicting results being issued in the future. For example, sulphonamide discs were used in two concentrations, the higher for topical antibiotics and the lower for systemic antibiotics. An isolate of *Staph. aureus* from an eye swab was reported as resistant to sulphonamides because the lower concentration had been inadvertently used but sensitive when the higher concentration disc was correctly used later; these results had appeared without comment on the reports.

An analysis of the percentage of each species of pathogen sensitive to commonly used antibiotics could be useful to the technical and medical laboratory staff and to clinicians. By MSB, with the staff available such an analysis was almost impossible to produce, but with CARF it was easily obtained from the computer files.

IN THE HOSPITAL

Medical and nursing staff liked the clarity of the computer-printed report; all but one of the consultants preferred the CARF report to the MSB report, but all clinicians preferred the MSB report to the MSA report. Three consultants valued a twice-monthly printout of CARF reports from their patients; such a service from a manual system would have required a photocopy of each report either at the time of issue or retrospectively after a search of the files for specimens sent by each consultant.

The control-of-infection sister appreciated the weekly printout of wound swabs, and also a printout of all specimens from one ward to monitor occasional problems of cross-infection.

COST

The development of CARF required for two years the salary of an analyst/programmer and one-fifth of a consultant's time. Computer time—at a cost of

£2000—was provided by the Medical Research Council. The microbiology COBOL programs were carefully structured so that data were rapidly processed with the minimum computer-time required for each run. Including the time for updating the files and assembling summaries, error and overdue reports, each computer report required 5·7 seconds computer time. The ICL computer was run under the George II operating system, and the charge for computer time was the commercial rate of £30 per hour—4·7 pence for each report. Each computer report cost 17·97 pence (table IV) and each MSB report cost 10·28 pence (table V). The decollator which separated the continuous-stationery reports and trimmed their edges was shared by three departments. The requirement of three office staff was the same for both systems, though their duties were of course different.

	Equipment	£	
	2 Olivetti tele-typewriters	2000	
	1 card-punch	1200	
	⅛ cost of decollator	330	
	15 Port-a-punch boards	45	
	Total	3575	
	Depreciation over 7 years—cost per year		£511
2	*Revenue*	£	
	1 data processing operator (DPO)	1850	
	1 assistant DPO/reception clerk	1650	
	1 departmental secretary	1850	
	½ time of divisional programmer	500	
	80 000 Port-a-punch cards	120	
	60 000 request envelopes and reports	1404	
	Paper for summaries and edit-sheets	51	
	Computer time	2849	
	Total	10 274	
	Total for 1 and 2	£10 785	
	Cost per report	17·97 pence	

Table IV *Computer costs—for 60 000 reports per year*

	£
3 office staff	5350
NCR request/reports	720
Paper for day-book, supplementary reports, etc	100
Total	6170
Cost per report	10·28 pence

Table V *Cost of manual system—for 60 000 reports*

Discussion

MSA COMPARED WITH MSB

Registration of specimens by MSB did not require photocopying and thus was a quicker procedure (table I); a shorter time was required to compose reports (table III). Medical staff preferred the printed format of MSB reports.

MSB COMPARED WITH CARF

Any manual method that includes hand-written elements may be unclear due to bad hand-writing, and errors may occur when information is transcribed from rough notes. Typed reports are time-consuming for office staff, and errors occur during typing. Printed forms containing lists of bacteria and antibiotics with rings or crosses against the actual results may be difficult for the clinician to decipher and may provoke requests for additional unnecessary sensitivity tests. Copies of laboratory reports are usually filed alphabetically, a procedure that requires clear and accurate patient details and a high standard of filing, for example to ensure that patients with similar surnames are separated between their correct forenames. The filing of many thousands of copies of laboratory reports by skilled clerical staff is wasteful of their talents; unskilled staff may perform such a monotonous task unreliably. In large alphabetical files misfiled reports are virtually lost. Isolations of interesting bacteria may not have been noted by laboratory staff, and an attempt to retrieve any group of such isolates is almost impossible in an alphabetical file. A decision whether to use a manual or a computer reporting system depends on a balance between what is required of the system and what it costs. The purpose of this paper is not to provide an answer to this problem—which must depend very much on local circumstances and resources—but to provide some information that may be useful to those who have to make a choice between manual and computer systems for reporting and filing in a department of microbiology.

Registration of specimen details could be much quicker than in our CARF system, with an on-line computer file of patients' names and hospital locations; the DPO would register only the hospital number of the patient and the details of the specimen, and when the report was printed the patient's name, age, and sex, the name of the consultant, and the location of the specimen would be added to the report by the computer. Such a file would also avoid the error caused by the wrong SPC being put in the envelope, the DPO failing to note this, and the report having the wrong name. This discrepancy should be noted when reports are signed, but could be missed. The value of an on-line system for recording results by technicians was mentioned by Goodwin and Smith (1976); many errors would be detected immediately, and time would not be required to correct rejected cards.

For a manual system the main advantages are simplicity, familiarity, and cheapness. The system does not depend on machines that require skilled operators, and reports are not delayed by machine breakdown, operator error, or data incorrectly submitted. The system is relatively versatile and the format can be changed fairly easily.

For our computer system the advantages are:

accuracy of reports, faster and more accurate filing and recall of reports, a greater range of services and analysis of reports, and an extra, cumulative list of reports that could be examined by members of the department instead of requiring the office copies (Goodwin and Smith, 1976). The greater accuracy of computer reports may incline some microbiologists not to sign some types of reports such as on a urine without cells or bacteria. The report-print program could selectively print such reports at the beginning or end of the run, to be separated from the ones to be signed.

Errors of interpretation of the zone size of sensitivity tests in terms of sensitivity or resistance were found once in every 12 reports in a manual system, and these errors were eliminated in a computer system that interpreted zone sizes (Petralli *et al*, 1970). Our system used a similar technique to reduce such errors of interpretation.

As the number of specimens processed by a microbiology department increases, Andrews and Vickers (1974) have observed that pressure would come on a manual system that depended on typing reports, and mistakes might be more frequent. In a computer system, if more specimens result in more mistakes during registration of specimen details or by technicians these mistakes will be detected by the computer.

The time that was required daily—half an hour—for the microbiologist to monitor the computer system was probably justified by the improved service given by the department to the hospital—more rapid answering of telephone enquiries, high-quality reports, and the potential of avoiding delayed reports, as well as the compilations performed more easily by the computer than manually. The increased cost of computer reports might also be justified by the improvements just mentioned; but it is doubtful that a cost greater than 25 pence per report could be justified. By contrast with MSB, many CARF request envelopes could remain unfiled without causing a delay in answering telephone enquiries, but in fact such a backlog did not occur, partly because the numerical filing procedure was quicker than alphabetical filing.

A microbiology computer-system that did not meet the objectives described by Goodwin and Smith (1976) would probably not be acceptable in a microbiology department; but the system described here did not have any microbiologically undesirable features. To succeed in maintaining a microbiology computer system it would be necessary for the technicians to accept the constraints and for at least one or two senior technicians to have the will to understand its design to the same extent as the microbiologist understood it.

On balance we would say that a computer system should not be considered in a laboratory where the work-load is fewer than 25 000 specimens per year; it is worth serious consideration if work exceeds 40 000 specimens per year and may be essential if work exceeds 100 000 per year.

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